

FEATURE ARTICLE

COVID-19: 3D Printing to the rescue

LASER-BASED METAL 3D PRINTING:

Breakthrough in technology

CRAZIEST MATERIAL FOR 3D PRINTING SO FAR - LUNAR DUST:

Testing lunar dust composites for the ultimate goal of 3D Printing a moon base on the moon using moon dust.

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SELECTING PARTS FOR 3D PRINTING -A PRACTICAL GUIDE:

Step-by-step process of identifying parts that can be 3D printed and evaluating pros & cons of 3D printing them on a mass scale

3D PRINTING NEWS:

Latest developments in 3D Printing and its applications across the globe



Indian 3D Printing Network (I3DPn) is India's first dedicated 3D Printing initiative, acting as one point of contact for the Additive Manufacturing industry, with an aim of engaging the AM community.

TRADESHOW



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CONFERENCE



INDUSTRY REPORT













EDITORIAL

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With the onset of a new decade, we are closer to achieving Industry 4.0 and to be a front runner in doing so, India needs to pioneer one of the main pillars of Industry 4.0 - 3D Printing Technology.

To fuel this achievement, incorporated the Indian 3D Printing Network - a one stop solution to everything related to 3D Printing. This called for undertaking new initiatives which would empower the Indian 3D Printing industry.

Thus, **AM Chronicle** was born. The idea behind AM Chronicle is to make content dedicated to Additive Manufacturing available on a single platform.

Under AM Chronicle, we currently have a content portal - amchronicle.com. However, we felt the need for a more dedicated thematic publication that would highlight big developments and bring dedicated insights and market information from industry experts.

Born out of this very need, is our new publication - a quarterly technical magazine on Additive Manufacturing and an extension to our media portal amchronicle.com - the **AM Chronicle Journal**. This journal aims to be the essential voice for the Indian Additive Manufacturing industry and provide thought provoking content for readers.

Despite being a time of uncertainty and despair, we couldn't have launched the first issue of the AM Chronicle Journal at a better time. COVID-19 has brought the world to its knees. However, the global 3D Printing community has risen in support of the medical industry, like never before. This issue highlights how 3D Printing has come to the rescue against COVID-19 on a global scale by 3D Printing essential medical equipment in record time, thereby reducing the demand and supply gap, considerably. The issue also highlights new technologies and new material beside giving industry insights.

Despite the challenges faced due to remote working, our team has worked hard and we are happy to present this new initiative under the Indian 3D Printing Network banner.



Aditya Chandavarkar Co-Founder Indian 3D Printing Network

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3D PRINTING NEWS



Additive manufacturing (AM) is the technical nomenclature used to refer to the group of technologies used to build objects or parts by addition of material in layers.

AM is defined as a process to make parts from 3D model data, usually layer upon layer, as opposed to technologies like subtractive manufacturing and formative manufacturing.

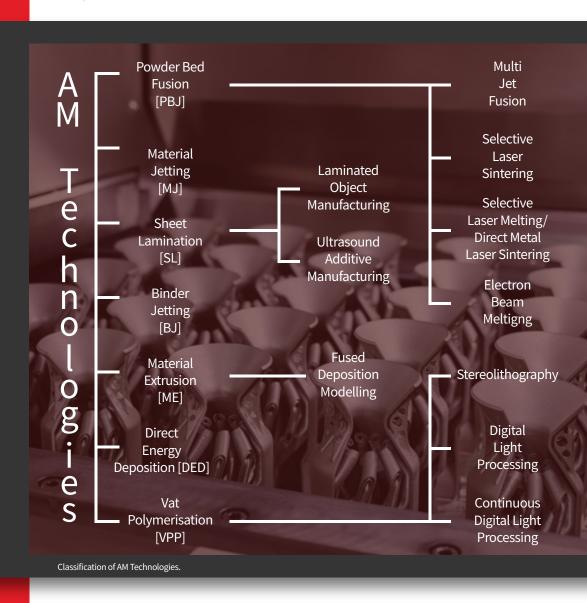
Historical terms: additive fabrication, additive processes, additive techniques, layer manufacturing, additive layer manufacturing, solid

freeform fabrication and freeform fabrication.

Companies generally tend to market their own version of AM nomenclature using their trademark names, most of which are just subtle variations. A few companies also utilise a combination of different technologies within the different classifications (HP and their Multi Jet Fusion machines is an example), though these are far & few when compared to other machines available on the market.

AM is defined as a process to make parts from 3D model data, usually layer upon layer, as opposed to technologies like subtractive manufacturing and formative manufacturing.

Major classification of AM technologies along with their definitions according to the ISO/ASTM 52900 Standard are mentioned below (Refer to Graph 1 for a landscape view):



Vat Photopolymerisation: Process in which liquid photopolymer in a vat is selectively cured by light-activated polymerisation.

Material Extrusion: Process in which material is selectively dispensed through a nozzle or orifice.

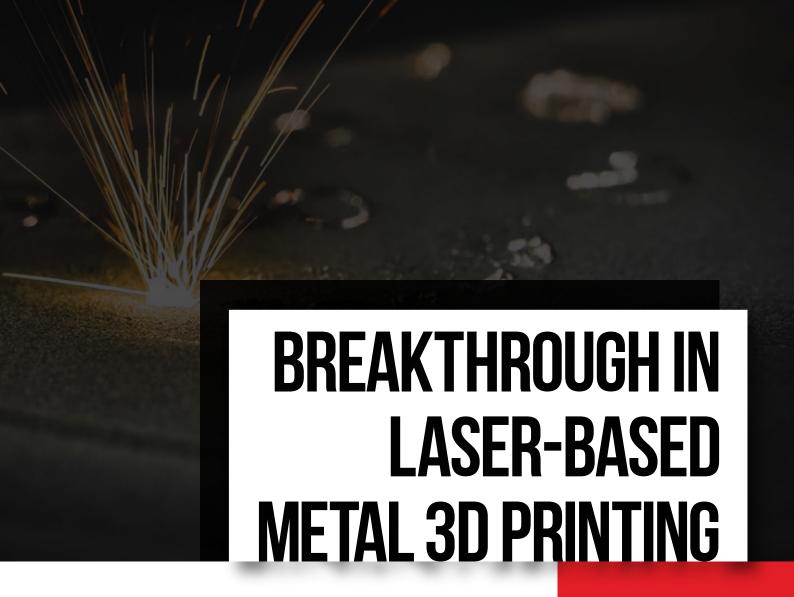
Material Jetting: Process in which droplets of build material are selectively deposited typically using inkjet printing technology.

Binder Jetting: Process in which a liquid bonding agent is selectively deposited to join powder materials.

Directed Energy Deposition: Process in which a focused thermal energy is used to fuse material by melting as they are being deposited. Focused thermal energy means that an energy source (e.g., laser, electron beam, or plasma arc) is focused to melt the materials being deposited.

Powder Bed Fusion: Process in which thermal energy selectively fuses regions of a powderbed.

Sheet Lamination: Process in which sheets of material are bonded to form an object.



3D printing technology might have been path-breaking but technology has it's limitations and in the case of metal 3D printing some metals couldn't be used. Copper was such metal. Given commonality of copper in engineering instrumentation, 3D printing some of the most common tools used in various related engineering professions was not achievable.

A research team at LLNL, along with collaborators at the Air Force Research reveal Laboratory, previously unknown dynamics involved in the laser powder bed fusion additive manufacturing (LPBF-AM) process, which uses a laser beam to melt metal powder layer-by-layer to form 3D parts. These newly discovered mechanisms produce 'spatter' particles or clusters of powder

potentially leading to pore formation and defects.

To better understand these laser spatter interactions and the broader problem of certifying parts printed though LPBF-AM, LLNL researchers used computer models to create a 'digital twin' of the process, which they used to perform virtual experiments of builds at the microscale. By comparing the simulations to experimental data captured using high-speed X-ray and optical imaging under LPBF-AM conditions, researchers developed a stability criterion resulting in a 'power map.' The power map is a scanning strategy that adjusts the laser's power output along the laser track to stabilise the melt pool. It is a key building block to establish 'intelligent feed-forward' a design process championed by LLNL that combines advanced modelling &

simulation with experimental analysis to teach 3D printers to efficiently create parts without defects.

When utilised, the stability criterion can reduce or completely eliminate the appearance of pores, keyholes (a deep and narrow melt pool) and other below-the-surface phenomena that can result in defects, researchers found. Additionally, they discovered that pre-sintering the metal powder running a multibeam laser over the powder at a low power to fuse the particles together prior to the build also can help reduce spatter and minimize the 'snowballing effect', where large spatter appears over the powder bed and becomes difficult to get rid of. Researchers said the strategy will improve overall part reliability and help enable wider adoption of additive manufacturing technologies.

"Spatter is the enemy of building nice parts; it's not just small particles flying around, they can create a system of classes of spatter that can affect the build in different ways and scenarios", said Saad Khairallah, the paper's lead author and LLNL computational physicist. "People can't just naively turn on their laser and start scanning, because the scan strategy can create spatter at the start of a track, beyond a size threshold, that can be very bad for the build. The good news is that by using this stability criteria that we describe in the paper, they can modify the scan strategy based on a controlled power map they apply to prevent that large back-spatter."

The most popular metal 3D printing process, LPBF-AM employs a laser beam to scan 2D patterns over a flat bed of microscopic metal powder to form melt tracks that fuse with the lower layers, repeating the process thousands of times to produce a 3D object. Despite its apparent simplicity,

the process still faces challenges for widespread adoption due in large part to the 'variability' problem, where the same 3D printing machine, using the same powder and parameters, can generate parts with varying quality.

Taken alone, experiments cannot fully explain the dynamics behind the process, Khairallah said, because they often lack the required spatial and temporal resolution, along with interpretation of the highly dynamical and transient LPBF-AM events observed experimentally, which necessitates advanced modeling. He also said complementing experiments high-fidelity multi-physics with simulations will allow researchers to capture what is happening at the powder bed level and below it in the melt pool, at very high speed, providing an indispensable tool for solving the variability problem and improving the part certification process.

To create high-resolution models capable of simulating temperature, velocity and other aspects of the laser/melt pool interaction, Khairallah developed new capabilities in a LLNL multi-physics simulation code called ALE3D, to capture the impact of the laser's rays on the expulsion of particles and other dynamics that generate defects such as 'laser shadowing', where melted metal powder can block/eclipse the laser.

By comparing the simulations to real-world experiments, it was concluded that shadowing creates a sudden decrease in the melt pool depth, in turn creating pores in the melt pool — larger the spatter, more shadowing that results. They also discovered 'self-replication', a phenomenon where the laser hits a large spatter site (spatter sitting on the powder bed) and splits it, causing additional spatter

sites to disperse over the powder bed and creating the snowball effect.

The intensity of the impact on the build is dependent on a certain threshold in laser diameter and power, the team found. High laser power is useful for expelling spatter that could block the laser, Khairallah said, but if the laser power is ramped up too quickly, or is too high, it can respectively produce large back spatter and keyholes. The power map the researchers devised, dynamically adjusts power along the track, finding a 'sweet spot' that can keep the melt pool stable, expels spatter that blocks or shadows the laser and can prevent spatter from becoming too large.

To validate the simulations, the researchers compared them ultrafast X-ray imaging data recorded under in situ conditions at the Advanced Photon Source synchrotron at Argonne National Laboratory and high-speed optical images captured at LLNL.

"X-ray diagnostics provide the only techniques that can simultaneously probe the surface and sub-surface of the metal while also offering the fidelity to track the fast dynamics of laser-induced structural changes," said co-author Aiden Martin, technical lead for the synchrotron experiments. "The use of X-ray imaging permitted us to experimentally observe the spatter



Printing platform with object printed on 3d printer for metal and covered metallic powder

"With our map, you can devise new scan strategies or adapt existing ones that maintain stability to prevent pores and defects." Khairallah said. "In the future, someone could take this simulation model and run it for any scan strategy and figure out the optimum power they need to use along the scan track. If you're doing a spiral or complex geometry, where the heat doesn't dissipate quickly, it will tell you how to adjust the power at these bottleneck regions."

formation phenomena and shadowing explored in the ALE3D simulations."

The capability for synchrotron-based X-ray imaging was provided by an experimental test bed developed under the Laboratory Directed Research and Development (LDRD) program and an existing LLNL ultrafast detector array that together enabled unprecedented temporal and spatial resolutions for probing sub - surface

LPBF-AM phenomena.

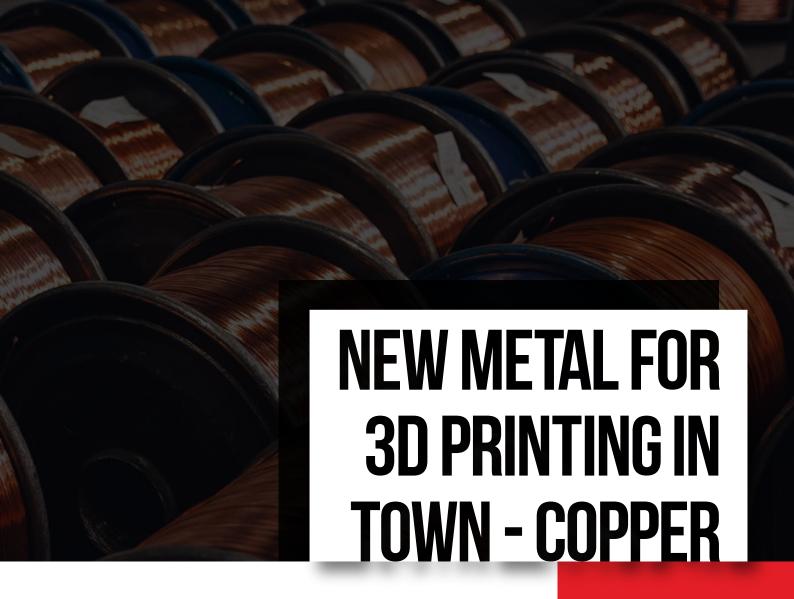
"An exciting breakthrough of the project was the ability to collect data with comparable time and length scales to simulations of equivalent laser-metal interactions," said Jonathan Lee, principal investigator of the X-ray research. "The synergy between LLNL experimental and modeling efforts was invaluable in developing new understanding of multiple LPBF-AM phenomena."

The complex and nonlinear transient physics behind defects require full-fledged codes to model complex events, Khairallah said. The criteria the team developed can be adopted by commercial codes, researchers said, and could be implemented into any metal 3D printer and could also apply to laser/beam based welding or fusing

technologies...

The high-fidelity modeling of thermal history and hydrodynamics using ALE3D forms the basis of a "digital twin" representation of AM materials, one of the main themes in a LDRD-funded Strategic Initiative aimed at controlling solidified mechanical microstructure and properties.

"Local control of energy input to the system using validated models opens up pathways not only to defect mitigation but to material enhancement through microstructure engineering," said Manyalibo "Ibo" Matthews, principal investigator of the Strategic Initiative LDRD & project lead for the Lab's Accelerated Certification of Additively Manufactured Metals project.



3D Printing might have been a path-breaking technology at the time but like every technology, this one too had it's limitations. One such limitation was in metal 3D Printing, wherein some metals couldn't be used.

Copper is a very reliable metal with innumerable applications due to its conductivity properties and for being highly malleable. Interestingly, these very properties hindered its success as a feasible option for 3D Printing. Given the commonality of copper in engineering instrumentation, 3D Printing even the most common tools

used in various engineering related professions was not achievable. However, that isn't the case anymore. The solution that researchers came up with to make Copper a viable option, is quite interesting.

Most common 3D Printing Technique - with a twist

The most common technique for 3D Printing Copper is Powder Bed Fusion. It uses electronic beams to melt material powders and 'glue' the material. When the temperature drops, the material consolidates together.

Copper's very properties of thermal & electrical conductivity and malleability, which make it an extremely reliable metal, hindered it's success as a feasible option for 3D Printing.

The most popular processes of Powder Bed Fusion are known as Selective Laser Sintering (SLS), for plastics, and Selective Laser Melting (SLM), for metals. Despite SLM being an excellent printing process for many metals, there was a particular challenge when it came to 3D printing with copper.

It's conductivity properties cause the heat from the electronic beams to be reflected instead of being absorbed.

Another reoccurring problem was the fact that the printed part would crack when the temperature would drop too fast and/or too low.

In 2018, researchers from the Fraunhofer Institute in Germany defied the status quo and developed a technique that made 3D printing high-quality copper parts possible. Their solution consisted of switching the infrared laser from an SLM machine with a green laser. It sounds simple, right?

vacuum. Each type of laser projects a concentrated beam that is amplified using stimulated radiation.

The light from this green laser for SLM printers developed by the German institute is better absorbed by copper which facilitates the melting of the material.

This took care of the issues caused due to copper's conductivity properties. But the issue of cracking due to temperature drops was still there. The solution was to pre-heat the material before starting the printing process, which is sufficient to avoid a huge temperature drop.

This technique comes as the first real alternative for copper 3D printing, presenting a fantastic opportunity for manufacturers.

Special Copper & Copper alloys

Once copper was available for 3D Printing, the demand for it skyrocketed.



Green Laser on Copper Powder Bed. (Credit: Fraunhofer Institute, Germany)

It is a bit more complex than that. Wikipedia teaches us that laser is an acronym for Light Amplification by Stimulated Emission of Radiation. In short, lasers are light sources characterised by their wavelength in a

To anticipate the demand for copper in AM, different companies are developing special copper and copper alloy powders for the 3D printing market.

Heraeus, a German technology group, developed a highly conductive copper powder with 99.8 percent density of solid copper and conductivity of about 95 percent IACS (International Annealed Copper Standard. Around 85 percent IACS is customary in the market.)

Oerlikon, from Pfäffikon (Switzerland), is a material manufacturer for aerospace, automobile, energy, and tooling industries. Among it's alloy portfolio, is CuNi2SiCr - a thermally curable copper alloy developed specifically for AM applications.

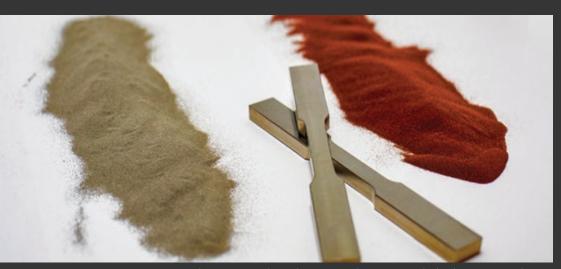
Machine and material manufacturer, Stratasys is also offering copper as a 3D print material, with Copper (C18150) and a chromium-zirconium copper (CuCr1Zr) alloy in its portfolio. The material has been tested with aerospace companies.

Another extremely interesting alloy in development is a titanium-copper alloy. Titanium has excellent corrosion resistance and the highest strength-to-

density ratio of any metallic element making it eligible to produce strong, lightweight alloy combinations. However, many titanium alloys used in additive manufacturing often bond together in column-shaped crystals during the printing process, resulting in adverse grain structure making them prone to cracking or distortion and thus susceptible to material failure.

But the titanium-copper alloy developed in a collaboration between reseachers at the Australian Royal Melbourne Institute of Technology (RMIT), the Commonwealth Scientific & Industrial Research Organisation (CSIRO), the University of Queensland, and Ohio State University in 2019, appears to have solved this problem.

Scientists are currently engaged in extensive investigations to determine properties of this alloy. More research to further improve on these by adding additional elements or using heat treatments will be done soon.



3D Printed Titanium-Copper bars with Titanium powder & Copper powder. (Credit: RMIT University)

With copper in picture, the application options have increased exponentially from manufacturing standpoint, as components used across industries from transport to electrical need/use copper. It is now possible to design electrically working pieces of equipment using a simple metal 3D printer.



Now that we are all caught up with copper being a reliable 3D Printing material, here's crazy material being considered for 3D Printing - Lunar Dust.

It's not science fiction, but a nearfuture scenario involves a 3D printer prototype being tested on the Moon.

Two of the biggest problems space exploration always faces are the limitations linked to procurement time and the high costs of sending material into space.

A more feasible alternative would be looking at exploiting the few resources available in an extra-terrestrial environment by developing new production technologies.

Thus began the study of determining feasible conditions for processing regolith (lunar dust) simulant via laser

powder bed fusion.

Joint project between the Italian Space Agency (ASI), the European Space Agency (ESA) & Politecnico Di Milano (Italy)

A PhD student in Advanced and Smart Manufacturing from the Department of Mechanical Engineering at Politecnico Di Milano, Leonardo Caprio, started the research of processing regolith simulant via laser powder bed fusion. He prepared a feasibility study of the 3D printing process using lunar dust simulant NU-LHT-2M for the construction of structural components.

The research is part of a project coordinated by Bianca Maria Colosimo, Professor at the Dept. of Mechanical Engineering (Politecnico di Milano), carried out with the Italian

Space Agency (ASI) and European Space Agency (ESA). The project saw the collaboration of Barbara Previtali Mechanical (Department of Engineering), who developed a prototype 3D laser beam printer capable of printing regolith, and the group Michèle of Lavagna (Department of Aerospace Science and Technology), which provided the lunar dust simulant, supported the experiments and conducted the final printed product tests.

The research concluded that regolith (the scientific name of lunar dust) could be used in 3D printing by compromising laser parameters and process conditions. Following these positive results, it was possible to define guidelines for the design of a future 3D printing system for use in space.

Politecnico Di Milano is one such project.

Another project involves concrete made of human waste and lunar dust. ESA scientists think that human waste can be used to make some robust concrete to 3D print habitats and create a lunar base. According to the study, urea would be a good 'superplasticizer' for lunar geopolymer mixture to make habitats on the Moon.

Lunar geopolymer mixture is a construction material similar to concrete. So, just as concrete needs water, this lunar geopolymer mixture also needs a plasticiser to make it more malleable before it can be hardened into a structure.

Researchers tested the use of urea as a plasticiser as it 'is the second most abundant component in urine (water

PhD student Leonardo Caprio's research concluded that regolith (scientific name of lunar dust) could be used in 3D Printing by compromising laser parameters and process conditions.

"The system's energy-efficient laser-based architecture must be simple and functional to allow a transition from a laboratory prototype to a system for real off-world applications," said the doctoral student and researcher, Leonardo Caprio.

This is where it gets crazier - addition of human waste to the mix - creating the Superplasticizer

The European Space Agency is involved in multiple research projects that involved 3D Printing with the goal of finding the most building a base on the moon. The joint project between the Italian Space Agency (ASI), the European Space Agency (ESA) & Italy's

being the most abundant)'. It will be readily available if there is human presence.

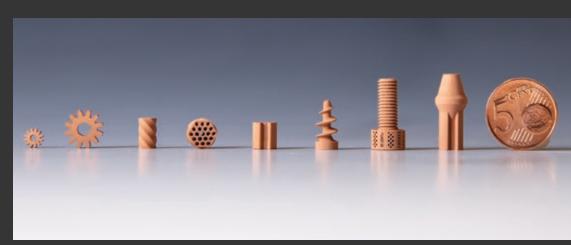
The process to make lunar geopolymer mixture mainly uses materials available on-site thus reducing the need for large amounts of supplies to be launched from the Earth. This is known as *In-Situ* Resource Utilisation (ISRU).

According to the ESA, the mix was used to 3D Print samples which proved to be stronger & retained good workability. These samples were able to retain their shape even while supporting up to 10 times their own weight. Further tests with vacuum and temperature variations showed that

the structures made from this building material would hold-up against the vacuum and temperatures that are in space.

The initiator & co-author of this study, Marlies Arnhof (ESA Team of Advanced

Concepts) said, "The science community is particularly impressed by the high strength of this new recipe compared to other materials, but also attracted by the fact that we could use what's already on the Moon."



3D Printed Ceramic Parts Made From Lunar Regolith (Credit: ESA)

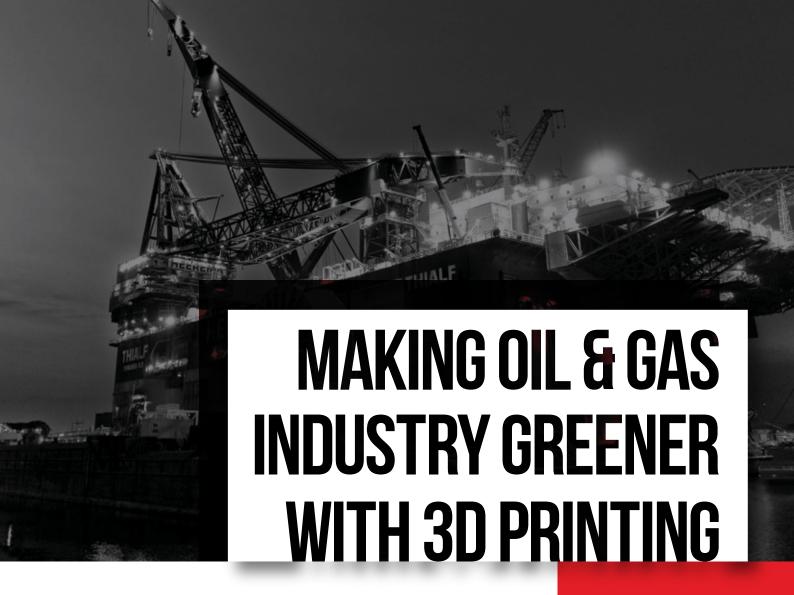
Both, private and government space agencies have expressed serious intentions and started developing plans to build a human-inhabited base on the moon. And 3D Printing is the way to go about it.



3D Printed Lunar Base Design. (Credit: ESA)



Concept Render - Lunar Base Made With 3D Printing (Credit: ESA)



- Additive manufacturing could boost efficiency and help to decarbonize oil and gas operations.
- It could also mean equipment makers and suppliers reinventing their business models to integrate just-in-time manufacturing.
- DNV GL is leading collaborative projects to evaluate applications of additive manufacturing technologies and build trust in them.

Additive manufacturing — the more sophisticated, industrial equivalent of 3D printing — could become the most disruptive technology the oil and gas industry has ever seen for sourcing and using materials. The potential efficiency gains include shorter lead times for sourcing parts, and less need for storage as digital design files replace physical stock. By enabling production, additive manufacturing could also eliminate the need to transport some components, thus reducing the carbon footprint of operations.

The key is using digital designs to direct the printing of physical parts, larger structures, or additional layers of materials. The raw materials include, among others, plastics and metals, typically supplied as powders & wires. User friendly digital platforms can connect files, machines and users to facilitate the sharing of digital files within organizations and among their supply chains. This can enable efficient optimization of design and manufacturing.

Iterations can be tested rapidly. There

is no need for costly retooling of machines as in car manufacturing, for example. Driven by digital connectivity and the distributed manufacturing capabilities of additive manufacturing, making equipment and components could shift away from centralized manufacturing. It could move instead to locations exactly or close to where the products will be used, such as on an oil platform.

generate revenue in markets where they are currently unable to supply spare parts on demand," said Sastry Kandukuri [Principal Specialist at DNV GL's Global AM Centre of Excellence] DNV GL's Global AM Centre of Excellence advises manufacturers. "In some of these places, there are 'grey' markets in non-OEM parts."

To recapture market share, OEMs can take benefit of emerging digital supply

It is easy to envisage additive manufacturing technologies helping to extend the functional life of ageing oil and gas assets"

- Brice Le Gallo [Regional Manager (South East Asia and Australia) DNV GL – Oil & Gas

"It is easy to envisage additive manufacturing technologies helping to extend the functional life of ageing oil and gas assets," said Brice Le Gallo [Regional Manager (South East Asia and Australia), DNV GL - Oil & Gas]. "For some, replacement parts are hard to get or make, but keeping stock for spares that may never be needed is expensive. It is not just about whole form of additive manufacturing could potentially add new material to an eroded area. This could extend the lifespan of that part and reduce the lifecycle cost of equipment."

Additive manufacturing also presents potential challenges and opportunities for the business models of original equipment manufacturers (OEMs) in the oil and gas industry. One common model is to make and deliver equipment, then collect after-sales revenue by supplying spare parts to local or regional resellers. Another is to supply equipment and keep it running efficiently over a contracted period.

"Some OEMs think it could help them

-chain platform models to protect their intellectual property (IP) rights. They would supply digital files securely to selected local resellers equipped with additive manufacturing capability, thereby reproducing parts legally and safely. This would reduce the cost of parts and boost their availability.

"These relationships need to be built on trust. OEMs want to protect their IP when sending design files to third parties," noted Kandukuri. "Key questions include who should be responsible for the part working, and for how long? Who should offer the warranty? If it is the OEM sending a design file, what do they need to know, and what needs to happen, all the way through to printing, for it to still be a part that the OEM is comfortable about its name being on?"

"Some software solutions for IP protection in additive manufacturing involve using blockchain technology for auditing the life history of designs and parts," said Pamela Joslyn [Senior Software Developer, DNV GL].

Some OEMs foresee themselves being rewarded for their designs by receiving royalties for each part printed and/or sold, said Kandukuri: "However, some end users tell us that when they buy equipment they also want to receive design files for spare parts. They hope it would mean them not having to rely in all cases on supply chains set up by OEMs."

Early interest is evident among Oil & Gas operators.

Adoption of Additive Manufacturing is in its infancy in the Oil & Gas industry. BP, Shell and Woodside are among the widely cited, but as yet few, oil and gas operators pioneering its usage.

"The industry has traditionally been conservative in the speed with which it will adopt new technologies," noted Le Gallo. "However, the new oil price era, and the competitive and regulatory forces in the energy transition mean the industry needs to keep raising its efficiency and competitiveness through technological innovation."

Additive manufacturing presents an opportunity to do that, he suggested. "Oil & gas sector companies can shape the technology to their purposes as they begin to adopt it, while learning from each other and other industries. Aerospace is quite advanced in this regard. Others, such as maritime, are also beginning the journey, and their experiences will have synergies with those of oil and gas, with which they overlap in the offshore context."

New collaborative project evaluates Additive Manufacturing

Illustrating Le Gallo's point, a programme studying the feasibility of the technology in the maritime industry is underway, with DNV GL leading the research at the company's

Global AM Technology Centre of Excellence in Singapore. The JIP (Joint Industry Project) will see DNV GL and 15 member companies of the Singapore Ship Association collaborate to see how printing spare parts can help the capital-intensive maritime industry cut costs and downtimes.

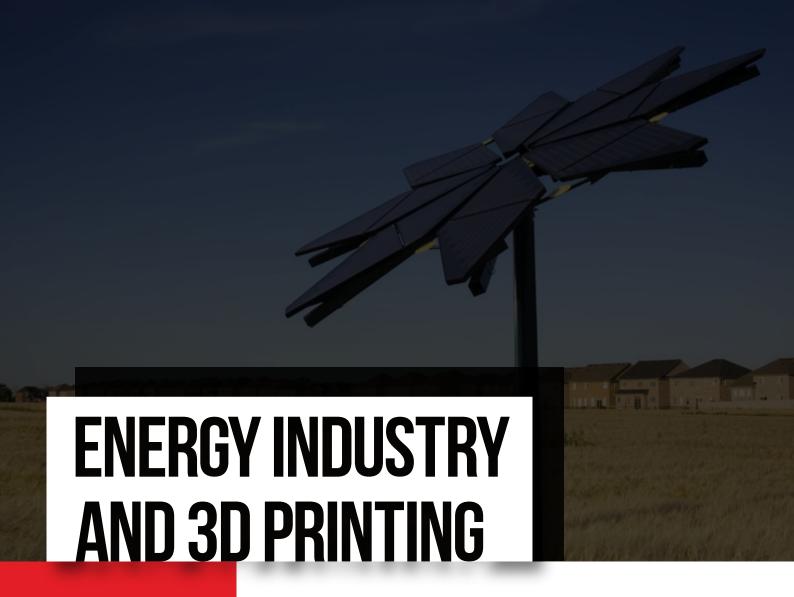
In another development, DNV GL and Singapore's Nanyang Technological University have signed a four-year research collaboration agreement, supporting academic advances in additive manufacturing for the oil and gas, maritime, and other industries.

A further 18 companies are involved in JIPs managed from DNV GL facilities in Norway, which have as their aims the development of a guideline and accompanying economic model to facilitate adaptation of 3D-printed functional metal parts for oil and gas, and maritime industries.

Additive Manufacturing offers huge savings to Oil & Gas companies.

While AM is in its infancy in the Oil & Gas industry, the potential rewards convince analysts that demand will develop rapidly. Market researchers SmarTech Publishing forecast that additive manufacturing by printing will become a US\$450 million market in the oil and gas industry by 2021, and US\$1.4 billion by 2025.

"The pay-off for operators and OEMs will be enormous once hurdles are overcome. The challenge now is to get everyone talking and looking at how to ensure that everyone benefits from this promising manufacturing technology. The JIPs that we are involved in and are planning through the Singapore facility aim to do just that," Le Gallo concluded.



Is there a better mass production way over traditional manufacturing? The past few decades, 3D printing has presented a potential solution to that problem, but only recently has the technology seen widespread development. 3D printing has so far been most useful for companies developing and testing new products, allowing them to make relatively low-cost prototypes.

Seeing the potential benefits, organisations around the globe are investing more in the technology. A study from Sculpteo found that in 2018, companies increased their investments in 3D Printing by 70%, up from just 47% in 2017.

Specific products are still being tested, but one area that stands to gain a lot from AM is the energy sector. The industry relies on complex equipment that has many parts, often used in rough and varying environments. Once fine-tuned, 3D printing could help companies produce more, faster and at a lower cost.

How 3D Printing Can Power Renewable Energy?

The energy industry is in a state of transition, shifting to more renewable and sustainable sources of power as global concern over climate change rises. One of the biggest challenges of this transformation is producing the equipment needed to harness resources such as wind and solar energy and turn them into power for homes and businesses.

3D printing can play an important role in keeping costs in line. Printing solar panels can cut manufacturing costs in half. In addition to production savings, MIT researchers claim the printed panels could be up to 20 percent more efficient than traditional panels. 3D printed panels are much thinner than traditional ones, allowing them to be easily transported without damage.

Wind energy also stands to gain from 3D printing. The U.S. Department of Energy's Wind Energy Technologies and Advanced Manufacturing offices have already partnered with public and private organizations spearhead the 3D printing of turbine blade molds. Manufacturing blades is a labor-intensive process, done mostly by hand. But being able to make the molds faster and more efficiently can go a long way to contain those costs. It helps curb transportation burdens, as sending a printer to a job site is much easier than sending a 50ft., mold.

Utilities Can Keep Older Machines in Working Order.

Anyone who has ever owned an old car or appliance knows that at some point, the manufacturer stops making parts for outdated models. While equipment should be updated to make sure the latest technology is being utilized, it can be frustrating for utilities to have to replace an entire piece of heavy machinery merely because one single part can't be fixed.

A 3D printer can make parts that have been discontinued, allowing expensive pieces of equipment to remain active safely. Future Power Technology reports that, in addition to replacing broken parts, 3D printing could also enable companies to make

parts that are unique to their needs and goals.

This could help each field of wind turbines or solar panels operate at peak efficiency. Siemens Energy Sector made the first 3D Printed metal replacement parts for an industrial gas turbine in 2018, noting that the milestone shortened the lead time on traditional production of the part by 40 percent.

Never Run Out of Needed Tools with 3D Printing.

It's not only parts that could be 3D printed to save costs — everyday tools that utilities burn through quickly can be printed as well. Multiple research groups are looking at ways to print batteries, which many manufacturers need in large supply to power tools, equipment and everyday office supplies.

For example, Manchester Metropolitan University is developing a 3D-printed battery from graphite that could potentially last longer than traditional lithium-ion batteries. Harvard University researchers are is working on a printed miniature lithium-ion battery, while IBM and ETH Zurich have 3D-printed the first liquid battery (which could produce power while it cools, potentially eliminating the dangers of overheating).

Being able to make batteries of any size and any power, with specific kinds of materials, could prove crucial for the future of the industry. The flexibility it provides, along with increased efficiency and costs containment, could end up being a game changer.



March 11, 2020 - the World Health Organisation (WHO) declared the Coronavirus (or COVID-19) outbreak a global pandemic. With over 45 million people affected, this COVID-19 outbreak is the biggest the world has seen in over a century, bringing the world to a standstill and the global economy to its knees in a matter of just 2 months. Global medical industry has been in doldrums ever since due to shortage of supply of equipment and machinery.

Up until about 3 months ago, 3D Printing was being adopted at a snail's

pace. However, the global shortage of medical supplies in the last 3 months has seen 3D Printing come to the forefront. From testing to treatment, 3D Printing has been meeting the needs of medical supplies across the globe. Space agencies, automakers, universities, startups, manufacturing firms, 3D Printing companies and more have all come forward to 3D Print medical supplies. Almost every 3D Printer on the planet is being put to this use.

As the famous saying goes, crisis is the mother of innovation. Despite a third

Global shortage of medical supplies in the last 3 months has seen 3D Printing come to the forefront. 3D Printing backed innovation has also seen an unprecedented rise.

of the world being in a lockdown, more innovation is seen on a day to day basis than before, across industries. From repurposing snorkelling masks for medical use to hands-free door knobs, 3D Printing backed innovation has seen an unprecedented rise.

A few updates from across the globe on how 3D Printing has truly come to the rescue against COVID-19 outbreak are as follows.

MEDICAL SUPPLIES MANUFACTURE

Proudly Made In India, Imaginarium PPE Goes Aggressive Against COVID-19

Imaginarium, India's largest Advanced Manufacturing and Rapid Prototyping Center, has announced its efforts against the COVID-19 pandemic by commencing the manufacture of PPE (Personal Protection Equipment) in its existing facility.

They have come up with a unique concept to protect the entire face of an individual by creating a face shield that completely covers the face including the ears and neck. With an ergonomic,

lightweight design, it is a product designed for comfortable usage during long working hours. The Face Shield is the first in a line up of products shortlisted by our team for design and manufacturing during this time. They have also been working on the development of Safety Goggles, Aerosol Intubation boxes, Ventilator Components and other critical supplies that can be distributed to every part of the country immediately.

Anatomiz3D's COVID-19 Action Plan: 3D Print Medical Supplies, Open Source Design

Anatomiz3D incorporates 3D printing technology to assist the healthcare industry, which can easily adapt as per the situation and requirement of various medical procedures. Since its inception, Anatomiz3D has established a firm foundation of customising and equipping with a personalised 3D anatomical models for intricate surgeries. They also make

customised titanium implants for neuro and ortho, to name a few among other purposes.

So far, they have delivered more than 50,000 pcs of Face Shield Masks, they are delivering these vital pieces of equipment to all the corners of India and if needed can transport the same to international COVID-19 hotspots across the globe.

Germany's Space Agency Shifts Its 3D Printing Resources To Manufacturing Protective Medical Equipment

German's space agency and NASA equivalent, is doing what it can to support the global shortages of personal protective equipment (PPE) used by frontline healthcare workers in their efforts to treat those affected by COVID-19. DLR announced that it has successfully tested converting its on-site 3D printers, typically used for

producing aerospace-grade parts, to creating medical equipment including protective face masks and ventilators.

So far, DLR can produce "up to 10 protective masks or 15 valves for ventilators per day," but it says it hopes to work on building out a network of facilities that can ramp up production to higher rates of output.

3D PRINTING BACKED INNOVATION

3D Printing Firm Releases Hands-Free Door Opener Design

Belgian 3D Printing company - Materialise has come up with a solution for door handles. The design is online now and free to download.

"The idea for the 3D Printed door handle originated at an internal meeting to define measures to protect Materialise employees & visitors", said the firm.

"It soon became clear that more people could benefit from this design and the company decided to make it available for free. Anyone with access to a 3D printer can download the design and 3D-print it locally in a matter of hours."



3D Printed Simple Tool Could Eliminate Direct Touch

Monash University PhD student, Muthu Vellayappan, has designed and 3D Printed a 'safety key' that can help people avoid direct contact with door handles, lift buttons, ATM digits, toilet flushers and hand dryers, and other surfaces where contamination may be present.

Vellayappan said the key has many functions and can work on L-shaped and U-shaped door handles commonly found at shopping centres, hospitals and universities, and in places of high pedestrian traffic.



3D Printed Plastic Key (Credit: Manmonthly.com.au)

3D Printing manufacturers across the globe are committed to supporting a united front to address shortages and rising demand triggered by COVID-19 to better help efforts that protect the lives of those impacted by this global pandemic.

The 3D Printing community is already mobilising resources to support critical needs. Additionally have initiated individual response channels wherein treatment centres can directly order medical gear. You can avail more information on this initiative including list of equipments 3D Printed by each company on the World Economic Forum's website. (weforum.org/covid-action-platform/projects/3d-printing-covid-19-rapid-response-initiative).



AUTHOR



Deelip Menezes (Managing Director, 3D Systems India) is an entrepreneur with over 22 years of experience in building and running Additive Manufacturing related technology companies, two of which were acquired by 3D Systems in 2011. Subsequently, he created and headed their subsidiary in India. Building engineering software and hardware teams, expanding 3D printer and 3D software sales channels, building

a service team to grow sales, enhance customer experience and strengthen customer confidence are some of his noteworthy achievements.

Rapid Application Group is a 3D printing service bureau based in Tulsa in Oklahoma, USA. They have been using 3D Systems SLS 3D printers to print urgently needed parts for the fight against COVID-19 like face shields & masks. These parts are printed using our Duraform PA 12 material which is capable of meeting ISO 10993-5 and

10993-10 standards for biocompatibility (cytotoxicity, sensitization and irritation). With a Heat Deflection Temperature (HDT) of 180 degrees Centigrade, parts can be sterilized using autoclave. For those who aren't aware, an autoclave is a machine that uses steam under pressure to kill harmful fungi, bacteria,

viruses, and spores on items that are placed inside a pressure vessel.

The reason I'm explaining this in detail is because I see a lot of well-meaning people with 3D printers eager to help in the fight against COVID-19. That is very heartening. However, we need to be responsible to print medical parts using the right technology and material depending on the intended application of the part. We need to realize that if a hospital is using a 3D printed part instead of a part made using a traditional method in a certified facility using a certified process, it means that they are desperate to do something to keep a very sick patient alive. They have obviously run out of their regular supplies or venturi valves for ventilators or face marks and shields and now the doctors need to take some very critical life and death decisions. These 3D printed parts are going to be used on a very sick person or by a healthcare worker who has run out of options.

To drive my point in, at 3D Systems we offer more than 130 materials across our six 3D printing technologies. But we recommend only a small handful of them for medical applications like parts for COVID-19 applications. For example, take a ventilator splitter which is used to serve more than one patient on a single ventilator. It is very important for the inner surface of the splitter to have a smooth surface finish,

similar to the kind you will get from an injection molded part. This is because a rough surface will not only mess with the air flow, but more importantly it will become a breeding ground for growth of bacteria. So if you use a 3D printing technology which doesn't yield a smooth surface finish then you may end up causing a bigger problem than you are trying to solve. A patient put on the ventilator could develop a secondary infection due to the bacteria in the splitter.

This is a very good reason why medical devices are put through a very stringent qualification and certification process. It takes months and sometimes years to certify medical devices. So my request to people with 3D printers eager to help in emergency situations like the one we have now is to take some time out and do some due diligence on the 3D printing technology that your printer uses. Get a deeper understanding of the material that your printer uses. Learn more about the best practices that you need to follow when post processing the parts that your printer has printed.

As an important step in becoming a doctor, medical students must take the Hippocratic Oath. One of the promises within that oath is "First, do no harm". Or "primum non nocere," the Latin translation from the original Greek. As the 3D printing community joins the fight against COVID-19 let us all take an oath to "First, do no harm".



AUTHOR



Dr. Atanu Chaudhuri is an Associate Professor of Operations and Technology Management at Durham University Business School, UK and an Adjunct Associate Professor of Operations and Supply Chain Management at Aalborg University, Denmark. Dr. Chaudhuri has more than 8 years of industrial experience, having worked in the automotive industry, consulting and research (in India) and over 9 years of

academic experience in India, Denmark & UK. He is also the Digital Supply Chain working group leader of the leading AM network - Mobility Goes Additive.

Additively manufacturing spare parts help in shortening lead time and thus avoid maintaining huge inventories. Companies exploring the option of 3D Printing spare parts face challenges in identifying suitable ones.

Additively manufacturing spare parts help in shortening lead time and thus avoid maintaining huge inventories.

A step-by-step selection process generally helps overcome this hurdle.

Step 1: Identify objectives

Some potential objectives for producing spare parts using AM can be

- Supply risk reduction
- Lead time reduction
- Inventory cost reduction
- Ensuring local content
- Minimizing loss of production
- Reducing carbon foot print across life cycle

Companies can decide the most relevant ones from those and provide relative importances of those using a method called analytic hierarchy process. Instead of directly assigning importance weights to each objective, experts within the company can make pairwise comparison of the objectives using a scale (eg. 1-3-5-7-9) and derive the importance weights.

Step 2: Identify factors for screening spare parts for AM suitability.

Factors to screen spare parts for AM suitability can be as follows.

- Demand & demand uncertainty of the parts
- Overall part size (Part must fit build volume of the equipment)
- Material
- Supply lead time
- Purchase price or unit cost
- Value of inventory across all locations

Step 3: Identify factors to be used for scoring spare parts for AM suitability.

Potential factors for scoring spare parts in terms of their suitability for AM can be as follows:

- Lead-time
- Unit Time

- Criticality in terms of influence of the part for equipment shutdown
- Demand predictability measured as standard deviation of demand
- Supply risk in terms of number of suppliers
- Minimum order quantity

The screened parts can be scored based on the above factors and how the factors are related to the objectives.

Parts with long lead time, high cost, high criticality, low demand predictability, high supply risk and high minimum order quantity in the existing manufacturing process will be more suitable for AM.

Step 4: Choose appropriate method for scoring the parts.

There can be multiple approaches to score the spare parts in terms of suitability to be produced using AM. Mentioned below are some basic guidelines.

- Multi-criteria decision making approach (MCDM) – scoring parts on factors and linking factors to be objectives (suitable for less number of factors and less number of parts)
- Logic decision diagrams, cluster analysis and fuzzy inference system (suitable for large number of parts, medium number of but strong interrelationships of factors and objectives). If the factors are dependent on each other and their influence on the objectives depends on the levels of factors i.e. low, medium & high, logic decision diagrams can be built to score a part using different decision rules. In terms of disagreement between experts about the relationships, the relationships can be expressed

as fuzzy numbers and fuzzy inference system can be used to score the parts.

- Cluster analysis and **MCDM** approach for ranking of part clusters and within cluster ranking of parts (large number of diverse parts, limited to medium number of factors and independence of factors). Such a method will be particularly suitable if trying to rank all parts together do not result in sufficient discrimination. This will indicate that there are possibly different clusters of parts. In such a situation, it will be necessary to cluster the parts, rank the clusters and then rank the parts within the clusters.
- Bottom-up expert driven selection using a questionnaire or selection protocol (no data available or not possible to do quantitative analysis). If no data is available in digital form to score the parts, it is prudent to use the expert judgment of the service personnel or maintenance technicians. But, as those persons may not be aware of AM technologies, it is important to demonstrate to them what is possible using AM through workshops and ask them to suggest spare parts, which they find most difficult to Companies can also potentially run internal competitions to identify some spare parts to start with.

It is important to note that the company should have data on the following factors to be considered for screening. If such data is not available or available in different IT systems or in physical form (material specifications & drawings with dimensions), it will be difficult to include those at the screening stage.

Step 5: Assess the impact of AM produced spare parts on performance objectives.

Once some spare parts are identified, the next step is to develop business cases for the parts. But, those can be done once the appropriate technologies and equipments are identified. For that purpose, a of database all available AM equipments, technologies & material they use, build chamber of the equipments, and the surface finish achievable, need to be documented. For the spare parts which are scored high in terms of their suitability for AM, the most appropriate technologies & equipments can also be shortlisted. Then total ownership cost based cost models need to be developed to understand the economic implication of producing parts using AM. The relevant cists which need to be considered are material, production, energy, labour as well as the savings in inventory & transportation costs over the lifecycle of parts usage for different demand scenarios. Quotes from different service providers can also be used as a reference for taking the final decision.

Once a company has done this exercise and identified a few feasible parts, machine learning techniques can be used to identify patterns amongst the most suitable to facilitate process automation when new parts are added to the portfolio.



AUTHOR

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Prior to joining Thyssenkrupp, Abhinav worked at Dell Technologies and McKinsey & Company for several years. Abhinav has an MBA (Gold

Medal) in Finance & Strategy from XLRI, India and a Bachelor of Technology (Gold Medal) in Metallurgical Engineering from IIT Varanasi, India.

Additive manufacturing (AM), more commonly referred to as 3D printing, has come a long way since its introduction in the 1980's, growing at over 25% per annum over the last 30 years and accounting for around \$14 billion spend in 2019. It has proven benefits in providing entirely new design capability, redistributing supply

chains closer to end consumers, and making manufacturing processes more efficient and sustainable.

Additive Manufacturing can help lower the cost of developing complex products, increase design freedom, thereby enhancing overall efficiency of the manufacturing process.



Applications range from rapid prototyping and designing to tooling and producing complex final parts in small batches across industries. Four sectors -- aerospace, industrial machines & tooling, medical/dental implants, and automotive - in particular account for nearly 65% of the global AM market.

Despite low current penetration levels, other sectors have equal potential to benefit from AM. For example, the maritime and the natural resources industries (mining, cement, chemicals, oil and gas) are characterized by geographic fragmentation and remote locations, posing challenges around logistics and inventory management of parts. The problem can be partly addressed by 3D printing and building a digital spare parts warehouse optimizing the overall inventory and cost of logistics.

While, there are still a few limitations that might make AM seem less attractive vis-a-vis conventional manufacturing for mass production, including high raw material costs, limited material diversity, lack of process know-how, need for process control including higher stability & repeatibiity and limited regulatory standards and accreditations. The technology is rapidly improving by the day and as with any innovation, the economics only gets better with increased adoption and usage. In our experience, the biggest roadblock for AM's adoption is not the technology itself but application of its know-how.

Companies looking to adopt AM need to follow a structured three step approach to unlock and capture value from their AM initiatives:

Step 1: Define the overall purpose & intent for AM adoption.

Before commencing any AM initiative,

it is important to define the value proposition from using the technology and its alignment with the overall strategic intent of the company. Ultimately, any AM initiative needs to address a current business need and make commercial sense. For e.g., some companies successfully use AM R&D and new product development while others use it for operational efficiency and overall supply chain cost reduction. Most of the prevalent AM applications today can be classified into four categories.

- Product ideation & prototyping (e.g., market requirement study, reverse engineering, product development)
- Tools fabrication & modification (e.g., complex jigs, molds with internal cooling channels, assembly fixtures, in process testing and quality inspection)
- Industrial production (e.g., distributed manufacturing small scale production, on-demand printing, high-mix volume serial production)
- Spare parts (e.g., aftermarket spares, obsolete part production, digital warehouse, supply chain optimization, remanufacturing and parts maintenance)

Step2: Form partnerships to de-risk exposure across AM value chain.

Given the lack of in-house AM expertise, partnerships are critical to de-risk investment, maximize success, and build know-how for most companies. Partnerships can be forged for each step of the AM value chain or for a combination of steps from part identification & diagnostic, design & engineering to printing & post processing and finally testing & validation of the AM part. They can also play a big role in building upfront.

capability and accelerate its adoption within the organization.

Step 3: Prioritize & execute AM initiatives based on risk adjusted cost analysis.

Most often, companies struggle in shortlisting and prioritizing the right parts or components for AM. It is important to define a structured approach to shortlist parts based on the net value generated from the AM project which is typically a combination of the following factors:

Net Value Generated from AM = Traditional cost of make or buy – Cost of AM + Value of additional benefits from AM – Costs of additional risks

While the standard costs of make or buy are well understood, it is often the other elements which are the hardest to quantify and can influence the overall business case. To make an informed assessment of the business case, additional upside of 3D Printing over traditional manufacturing process needs to be quantified. For example, quantifying the impact of weight reduction or reduction in sub-assemblies leading to lower in-process inspection cost, lower part suppliers and supplier management cost, or lower inventory and logistics costs or longer product life. Similarly, there are additional risks such as risk of build failure or design leakage or the risk of IP loss, which need to be quantified, too.

AM today represents less than 0.1% of \$12.7 trillion manufacturing output globally. If AM manages to capture even 1% of global manufacturing output, then the industry can attain annual revenues of over \$100 billion. While the short-term impact of AM might be overstated, the long-term impact will be profound and it will fundamentally change the nature of manufacturing and global supply chains in times to come.

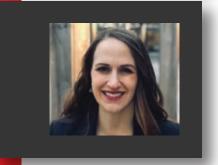




AUTHORS



John E. Barnes is the Founder and Managing Director of The Barnes Group Advisors, the largest independent AM engineering firm. He has a lengthy service in aerospace working to support prominent projects like the F-22, F-35, C-130J, X-47B and A350.



Jennifer Coyne is the Leader of Additive Manufacturing for the Wabtec Corporation and oversees multiple sites around the world in the United States, Europe and India.

The previous decade saw Metal AM maturing and being considered as a viable manufacturing process. Early in

the decade, many firsts were achieved largely through the powder bed fusion (PBF) processes. From 3D Printing gas turbine parts to bits that replaced human bone, we saw metal AM make an appearance just about everywhere clever engineers could make a case. By 2017, it had gained legitimacy as a real manufacturing technology. In 2018, we continued to see strong, but likely over-stated valuation and investment. 2019 will be remembered as the year businesses decided to treat it as a business.

The next decade will be where AM is less special and seen to be another tool in the manufacturing tool box. We're seeing 2020 as a sharp turn to get profitable using AM. Consolidation likely as we've seen the proliferation of metal AM manufactures rise from single digits in the early 2000's to over 30 today. However, as the vast investment in AM has outpaced demand we see the signs of a correction which will spur further growth. Finally, we will see a marked change in business needs from events and speakers who speak AM to events that help shape manufacturing.

To get a comprehensive glimpse of the trends in AM, we'll use five lenses: Machines, Material, Digital, People, and Geography.

Machines

People will get to know the other 6 forms of AM better. Mostly today, people know Powder Bed Fusion (PBF) or possibly Directed Energy Deposition (DED) but most of the manufacturing world knows very little. Machine competition increases and machine users will demand more. AM will learn a lot about manufacturing in the next decade, and benefit from conventional machine maker partnerships for industrialization and cost competitiveness.

Productivity will improve. Faster speeds, lower costs, more automation

and more build analytics will all greatly improve the manufacturer's life. Over time engineers will learn more how to design for AM which also help improve the utility of the machines as well as taking a whole of process perspective. Machines will also get more skills and more capability as more of the digital world converges into the machines.

Material

As the processes get better understood, our ability to use more materials will increase as well. Although linked to awareness and education, a better understanding of the product requirements therefore the materials performance required will help us better use materials in AM. As AM learns more about manufacturing, lesson learned from welding for example will be integrated. We will certainly see more material choice. As with the process, a whole of life perspective will find better understanding of material behavior, including optimization of thermal treatments. This combination will emerge as a way to get more consistency.

The AM community will seek better understanding of powder requirement for the process. This view will be less about controlling costs and more about getting the process under better control. The 'religion of the round' will be challenged!

Currently, the global AM market suffers from lack of locally produced approved material. As AM processes are further understood and powder requirements are refined, more local sources will become available, driving down material & import costs.

Digital

Innovation in software, CAD to CAM, & image processing, is top priority for propelling convergence of design and

and simulation tools into machines and how they operate. The design iteration process to and from CAD should get easier, with less disparate file types and tools.

Machine analytics to predict build success and material performance will increase. *In-situ* corrections will become possible, bringing a higher first pass yield and rate of repeatability.

Our line of sight to material performance data will increase as industry figures out how to pool data and resources.

People

Media attention will wane as the 'firsts' begin to become a common place. It will be interesting to see the impact on meetings, conferences & workshops.

The need for AM education and awareness across all business functions will increase. Businesses seeking to make money from AM will gain more focus very quickly and as the proverb goes, "fortune favours the

prepared".

Diversity will take a back burner. It will be a challenge to keep those young people involved in AM who were drawn to it initially once it becomes more mainstream. Hopefully, we will have learned a lesson on how to attract a younger and more gender diverse workforce but history tends to lean the other way.

Geography

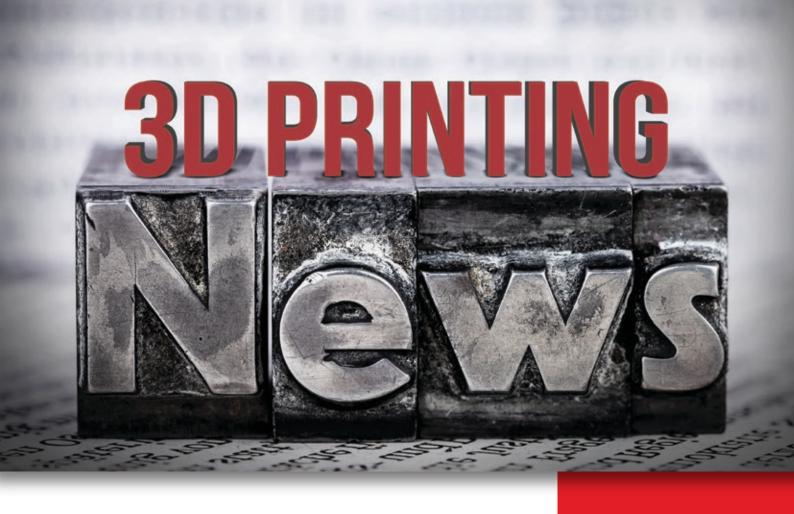
With initial market dominance occurring primarily in North America, Europe and China, other regions will see growth, and will be further spurred on by investment initiatives such as 'Make in India' and NAMIC Singapore.

Enhancements in automation and machine usability, coupled with pro-domestic manufacturing policies, will help AM enable certain regions to re-shore manufacturing. Re-shoring will reduce transportation costs, lead time, and increase the ability to adjust to changing market demands.

AM will be less special and more specialized. AM will start to be another tool in the manufacturing toolbox with less anxiety over how to traverse the paths of qualification and certification.

AM will be less special and more specialized. AM will start to be another tool in the manufacturing toolbox with less anxiety over how to traverse the paths of qualification and certification. AM will go more application specific, with value drivers triumphing over the appeal of new and different.

The technology is like a teenager. A little messy and a can be stinky, but you know they're going to be great one day and the investment in time is worth it. The 2020's will be bittersweet transition for AM. AM no longer gets by with just being special and new, it now must make business sense.



URBAN OWLS LOSING HOME -

3D PRINTING TO THE RESCUE.

Source: theconversation.com

Native to southeastern Australia, the powerful owl *(Ninox strenua)* is threatened and facing the prospect of homelessness.

What powerful owls need?

At a minimum, owl nests must provide enough space to support a mother and two chicks, shelter the inhabitants from rain and heat, and have rough internal surfaces for scratching and climbing.

Termite mounds in trees are oddly shaped, but they meet all necessary characteristics for successful breeding. This precedent suggests younger, healthier and more common trees can become potential nesting sites.

A high-tech home

To design and create each termite-inspired nest, first lasers were used to model the shape

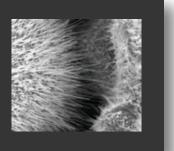


of the target tree. A computer algorithm generated the structure fitting the owls' requirements. Then, the structure was divided into interlocking blocks that could be conveniently manufactured.

To assemble the nests, augmented-reality headsets were used, overlaying images of digital models onto physical objects.

3D Printed wood has been used to build one nest at the University of Melbourne's System Garden. Two more nests made from hemp concrete are being tested.

Early results from data collection & analysis look promising, for now.



3D PRINTED NANOWIRE SENSORS

FOR DIABETES TESTS VIA BREATHE

Source: nanowerk.com

Aresearch team from Materials Science at Kiel University (CAU) and from Biomedical Engineering at the Technical University of Moldova has now developed a procedure to produce extremely sensitive and energy-efficient sensors using 3D Printing.

The sensor is able to precisely measure the concentration of acetone vapour using a special structuring at nano level. The highly sensitive sensors could determine acetone values of under 1 ppm (particles per million air molecules), reported the study, while the breath of people with diabetes type I or II has an acetone content of more than 2 ppm.

When organic molecules meet the numerous wires in the finished sensor, they react strongly to one another. By doing so, they change the resistance of the sensor and release clearly measurable signals. In principle, however, only a very small volume of electricity passes through the thin wires.

"So our sensors only use very little energy," explained Dr. Oleg Lupan - from Biomedical Engineering at the Technical University of Moldova. "This makes small portable measuring devices conceivable, too, which can be read directly via smartphone, for example."

The researchers hope this could enable future use of the sensors in mobile, portable breath tests for diabetics replacing the current method of testing blood sugar levels by pricking one's finger.



MARKFORGED - WÜRTH INDUSTRY

NORTH AMERICA PARTNERSHIP

Source: tctmagazine.com

Würth Industry North America has become the latest distributor of Markforged's metal and carbon fibre 3D printing systems.

The company is a renowned distributor of MRO and safety equipment, as well as supply chain solutions for the fastener sector, and will now begin supplying Markforged's additive manufacturing hardware to its customer base, many of whom operate in the automotive, heavy equipment and oil & gas industries.

With Markforged's composite and metal platforms, users will be able to print Fibreglass, Kevlar, and Carbon Fibre reinforced parts on the company's Industrial Series of machines, or 17-4 stainless steel and H13 tool steel on the Metal X platform. The company is also confident its customers will benefit from cost and time reductions.

"We're excited to expand the global reach of our

solutions with Würth and continue to push the bounds of what's possible in additive manufacturing," commented Greg Mark, CEO-Markforged. "This partnership truly opens up valuable potential for us and for the industry. Markforged makes it easy to build anything you can imagine. This capability enables industrial manufacturers to lower inventory costs by printing production tools & parts, quickly."

"We are thrilled to bring innovative digital supply chain solutions to our customers. By integrating Markforged 3D Printing technology with our existing Kanban programmes, we are able to offer quicker time to market and lower inventory costs," commented Dan Hill, CEO - Würth Industry North America. "We're able to cut out sourcing, purchasing & transportation costs and deliver the value directly to customers."

Kanban programmes include Kanban point-ofuse inventory systems, MRO supplies, fastener and assembly components, PPE equipment and quality control systems.

CUPRA ADOPTS AM - BOOSTS

SPEED, SAFETY & EFFICIENCY

Source: alphabet.com

A team of innovative engineers at CUPRA is transforming the way vehicles are developed by 3D Printing car parts.

CUPRA is using state-of-the-art multi-jet fusion technology to fashion parts in a fast and efficient way.

For its new Leon Competición racing car, engineers at CUPRA have 3D printed the model's door mirrors, air intakes and cooling intakes.

The technique enables the manufacturer to reduce the vehicle's fuel consumption while also increasing stability, speed and safety – vital in both motorsport and road car applications.

As the smallest margins can make the difference in motorsport, it is crucial the 3D printed parts play their part in reducing fuel consumption while also increasing stability, speed and safety.

Xavi Serra, Head of Technical Development - CUPRA Racing, said: "For the new CUPRA Leon



Competición we modelled the steering wheel's centre control module, the bonnet air vents, door mirrors and the brake and water-cooling inlets.

"The main goal is to have a lot of parts in a short time. We can quickly test a wide variety of designs and furthermore, this technology enables us to react swiftly to any changes in the design process.

"The bigger the variety of parts we can test in this facility, the better. It enables us to make much faster progress. The results were excellent, and some were even surprising, because we were looking to push the material to its limits.

"This technology is and will continue to be key in countless fields to make the most complex ideas a reality."

USE OF 3D BIOPRINTED BRAIN

TUMOUR MODEL FOR CANCER

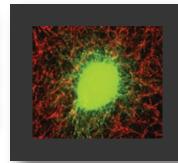
TREATMENT RESEARCH

Source: 3dprintingindustry.com

A group of researchers from USA & Germany have presented a new way to study Glioblastoma (GBM), an aggressive type of cancer in the form of a brain tumour, using a 3D bioprinted model and imaging platform.

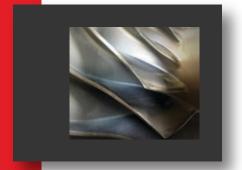
These 3D printed brain structures can help medical professionals better understand tumour growth and speed up discovery of potential new drugs to fight it. They are made from a collection of human brain cells & biomaterials, and feature perfused vascular channels allowing long-term culture and drug delivery, whereas the 3D imaging technology enables noninvasive tissue constructs assessment.

In order to study GBM more directly, Guohao



Dai, Associate Professor [Bioengineering] - Northeastern University, and his team 3D bioprinted an in vitro GBM tumour model with microenvironments that mimic the invasive tumour behaviors.

To accurately observe the developments inside the 3D model without disrupting it, Xavier Intes, Biomedical Engineer at Rensselaer Polytechnic Institute, scanned the sample using a laser, creating a 3D snapshot of the cellular structure. Combining this imaging technique with 3D bioprinting allowed the researchers to assess the tumour's respone to temozolomide - a commonly used chemotherapy drug, and evaluating its effectiveness in the process.



industries.

BEAMIT-TEMA ENERGY ALLIANCE,

3D PRINT GAS TURBINE ELEMENTS

Source: 3dprint.com

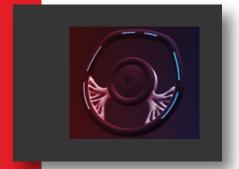
Italian company, BEAMIT SpA, has just announced a collaboration with fellow Italian company Tema Energy – to 3D print gas turbine components in order to better serve the aviation, power generation, and oil and gas

This new AM partnership will allow customers to access just one point of contact when they're in need of complex solutions. By working together to provide additive manufacturing, Tema Energy and BEAMIT can offer companies in the oil and gas, power generation, and aviation fields a better range of services, all the way from the smallest blade to full gas turbine

setups.

"After several years of cooperation in a wide range of applications, it became natural to join our forces with TEMA Energy where we found an excellent partner capable to provide leading expertise and competences in machining and post processing on key components. Our partnership will definitely benefit both current and future OEM's customers going forward in these sectors," Gabriele Rizzi, Chief Commercial Officer - BEAMIT, said in a press release.

"The cooperation with BEAMIT represents a step forward in the expansion of our business to cover new applications and markets.", said Paolo Zani, Chief Executive Officer - Tema Energy. "Customers can rely on TEMA Energy and BEAMIT as unique solution providers of a wider range of products and services."



ILLUMINATED STEERING WHEEL -

WITH 3D PRINTED ELECTRONICS

Source: assemblymag.com

End of 2018, Techniplas LLC, a global designer and manufacturer of automotive products and services, unveiled a unique steering wheel concept that combines its proprietary cognitive smart lighting technology with electronics printed on Nano's DragonFly Pro 3D printer. Engineers at Techniplas use this machine to directly print conductive paths into the steering wheel in one step.

The printer has two heads which enables it to concurrently print with nano-silver and dielectric polymer ink. This is an advantage Techniplas engineers like. Another benefit is being able to 3D print common PCB characteristics, like vias and through-holes, without subsequent etching, drilling & plating.

Powering the DragonFly, the Switch software lets users adjust many characteristics of the 3D file such as layer thickness & order, conductor

width, punching, rotation, and the shape or object outline. The software also has an interface that displays a detailed and accurate rendition of a design's structure to facilitate a precise 3D print job.

Experts at both companies are hopeful that combining smart lighting with additive electronics will shape and transform the future of mobility. They're convinced that merging these technologies will promote the creation of customized and short-run functional electronics like conductive geometries, PCBs, molded interconnects and other devices.

"We are excited about all the new applications that the cognitive steering wheel concept can bring to our [automotive] customers," says George Votis, Techniplas founder and chairman. "[This] concept is just the beginning of a journey that we believe can shape the way electronics, sensors, antennas and smart illuminations are designed and manufactured for the connected car era. We are thrilled to be the first with this capability in-house."

A NANO 3D PRINTER THAT

PRINTS NANO-SIZED OBJECTS

Sources: nanalyze.com, nanoscribe.com

Israeli 3D printing startup, Nanoscribe, has built the "world's highest resolution 3D printer designed for ultra-precise and rapid microfabrication." Dubbed as the "Photonic Professional GT2" this 3D Printer can create structures just 30 nanometers across. To put this in scale, a human blood cell is 8000 nanometers across.

Key features of the printer include -

- High-speed 3D microfabrication using galvo technology
- 3D design freedom with sub-micrometer feature sizes
- Straightforward 3D printing workflow from CAD-model import to printed product
- 3D Microfabrication Solutions Sets tailored to a variety of scales and applications
- Broad range of print materials and substrates.

The printer uses a Layer-by-layer Two-Photon



Polymerisation printing technology. In this technique, polymerisation of the photoresist is initiated by a two-photon process—i.e it requires the absorption of two photons at the same location simultaneously (or within a very short time of one another), hence the name - Two-Photon Polymerisation. This level of polymerisation occurs only in a small volume at the center of the laser focus where the intensity is high enough. By sweeping the laser beam through the photoresist, optical quality 3D structures can be reproducibly fabricated with voxel sizes down to ~100 × 100 × 300 nm³.

Nanoscribe offers an entire product family of resins and other materials that can be used to print the tiniest structures on a variety of different substrates like glass, silicon wafers, photonic, and microfluidic chips.

UNIVERSITY OF AUCKLAND

ENGINEERS CONSTRUCT A 3D

PRINTED ROBOTIC AIRSHIP

Source: 3dprintingindustry.com

Engineer duo, Gall Gorjup & Minas Liarokapis have designed and constructed a partly 3D printed robotic airship.

The first part of the project involved choosing the right lifting gas to fill the airship with. Gorjup and Liarokapis settled on helium over hydrogen and hot air due to its low density and lack of reactivity, making it a safe yet effective choice. Helium is non-renewable, however, choosing the right envelope material was also key to practicing financial and environmental responsibility.

Next, the mechanical properties and helium retention capabilities of a number of contender materials were tested and evaluated by the duo. They looked at untreated latex balloons,



latex balloons treated with Ultra Hi-Float, clear bubble balloons, and microfoil balloons. The lifting forces and surface areas of the balloons were measured daily over the course of 16 days. Eventually, the duo settled on microfoil for the envelope material due to its low strain rate, high tensile strength, and low cost.

The final portion of the project involved designing the gondola on the underside of the envelope. The gondola was 3D printed and housed a Raspberry Pi Zero W, the motor drivers, a set of DC motors, a step-up voltage regulator, three propellers and a camera to provide a dynamic viewing angle. The gondola was secured to the underside of the microfoil envelope with velcro straps.



UNDERWATER ROV BUILT WITH

FARSOON 3D PRINTERS

Source: 3dprintingindustry.com

that replaces ${\rm CO_2}$ laser technology with fiber lasers.

FIFiSH is this technology's latest application, with the firm having announced a development agreement with Swiss plastic 3D printing provider Rapid Manufacturing AG last October.

The 3D printed protective covers are a key design element to avoid potential damage to the thruster caused by impacts, collisions or fouling during the diving process.

They provide the mechanical strength and durability necessary to prevent damage to the thruster during dives of up to 100 meters, and temperatures ranging from -10 to 60°C.

Remote Operated Vehicle (ROV) manufacturer QYSEA is working with Chinese SLM and SLS 3D printer manufacturer Farsoon to produce protective covers for its FIFiSH V6 underwater ROV.

These customized covers, used for protecting the ROV's smart vector thrusters, are created using Farsoon's Flight additive manufacturing technology.

Flight technology by Farsoon, is a SLS (selective laser sintering) additive manufacturing process



NETHERLANDS BASED RESEARCH

TEAM DEVELOPS SELF-SENSING

3D PRINTED COMPOSITE PARTS

Source: 3dprintingindustry.com

A team from Netherlands-based Brightlands Materials Center has developed self-sensing 3D printed composite parts through the use of integrated fibers. The unique self-sensing characteristic of the parts is expected to enable sophisticated critical structure monitoring in sectors such as construction and prosthetics in the future.

3D printing would allow for the precise positioning of carbon fibers within a composite part, with placements and orientations running along critical areas where they are needed. The fibers could also be grouped together in batches to provide more sensitive monitoring where required – all made possible by the geometric freedom of additive manufacturing.

The Brightlands researchers conducted an experiment to validate their method of 3D printing sensor fibers by monitoring the deformation of a scale model pedestrian bridge. The bridge was simply a bending beam

made of a thermoplastic polymer matrix infused with carbon fiber. It was printed with the Anisoprint Composer A4 composite 3D printer, which allows for fibers to periodically be inserted along the build direction via co-extrusion, resulting in – you guessed it – anisotropy. Electrical connections were made with a few of the fibers protruding out of the bridge and their resistances were measured with varying applied loads.

The results showed a clear correlation between applied load on the bridge and electrical resistance of the continuous fibers, with resistance increasing as force increased. This validated the team's 3D printing of continuous fiber infused composites for self-sensing applications. Next step, real use circumstances, pf 3D printed self-sensing prototypes providing useful data on what sections of a component bear the most load or what range of forces the component will need to withstand. Engineers can use this data to design prosthesis to more efficiently distribute stresses or build bridging structures to support greater loads.

US ARMY ACQUIRES A NEW

\$15 MIL. STEEL 3D PRINTER

Sources: newscientist.com, digitaltrends.com

A giant, high-speed 3D printer is producing large, ultra-strong steel components and weapons for the US Army. It may also have non-military uses.

The prototype printer, commissioned from 3D Systems in South Carolina for \$15 million, can create objects up to a volume of 1 by 1 by 0.6 metres. The makers call it the largest, fastest and most precise steel printer ever made, big enough to print entire parts for military vehicles, such as hatches.

While the first working prototype printer won't be operational until this summer (pandemic complications notwithstanding), once it is fully operational it could be used to print steel alloy that is an impressive 50% stronger than the same material when forced or cast. That is due to the differing microstructure of the 3D printed alloy, created by layering powdered metal and



then fusing these layers together with a laser.

"Current commercially available laser powder bed printing machines have limited size for the build envelope which limits the applicability of the technology to a limited set of small — by Army standards — parts," Dr. Brandon McWilliams, metals additive manufacturing lead at the Army Research Laboratory, told Digital Trends. "A larger format machine opens up a much wider range of applications for increasing capability of the Army through the benefits of additive manufacturing for everything from manned & unmanned ground vehicles to next-generation munitions, [such as] warheads, missiles, [and] hypersonics."

COULD 3D PRINTERS CREATE

THE NEXT GENERATION OF

PARTICLE ACCELERATORS?

Source: scitechdaily.com

Imagine being able to manufacture complex devices whenever you want and wherever you are. It would create unforeseen possibilities even in the most remote locations, such as building spare parts or new components on board a spacecraft. 3D printing, or additive manufacturing, could be a way of doing just that. All you would need is the material the device needs to be made of, a printer and a computer that controls the process.

SLAC scientists and collaborators are developing 3D copper printing techniques to build accelerator components.

Diana Gamzina, Staff Scientist at the Department of Energy's SLAC National Accelerator Laboratory; Timothy Horn, Assistant Professor of Mechanical & Aerospace Engineering at North Carolina State University;



and RadiaBeam Technologies' research team dream of developing the technique to print particle accelerators and vacuum electronic devices for applications in medical imaging and treatment, the electrical grid, satellite communications, defense systems and more.

In fact, the researchers are closer to making this a reality than you might think.

"We're trying to print a particle accelerator, which is really ambitious," Gamzina said. "We've been developing the process over the past few years, and we can already print particle accelerator components today. The whole point of 3D printing is to make stuff no matter where you are without a lot of infrastructure. So you can print your particle accelerator on a naval ship, in a small university lab or somewhere very remote."



NEXA3D & HENKEL LAUNCH NEW

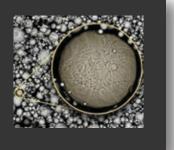
ABS RESIN FOR SLA 3D PRINTING

Source: 3dprintingindustry.com

Nexa3D, a California-based SLA 3D printer manufacturer, has announced it is working with leading global chemical company Henkel to develop a line of co-branded photopolymer SLA resins, which will be distributed through Nexa3D's global channels.

Through the newly established partnership, Nexa3D has now joined Henkel's open platform of material partners. Both companies intend to leverage their respective expertise in SLA 3D Printing technology and performance resins to create functional parts using Henkel's materials on the NXE400 3D printer. Their first material, optimized for the NXE400, is an ABS 3D printing resin developed with Henkel's Loctite material technology.

"Partnering with a great global powerhouse of the caliber of Henkel represents orders of magnitude of progress in our collective abilities to deliver additive manufacturing solutions that push the boundaries of what's possible with 3D printing for manufacturing," comments Avi Reichental, Co-founder & CEO of Nexa3D.



POROUS FREE METAL AM METHOD

DEVELOPED, HIGHEST TENSILE

STRENGTH TO DATE

Source: 3dprintingindustry.com

Researchers have found a way to 3D print steel free from porosity. Of all the combinations and variants of modern steel, martensite shines due to its high strength, ductility, relatively low weight, and cost-effective production. 3D printing complex structures can have an effect on the strength and durability of any material, however, so researchers from Texas A&M University found a work-around for this.

The team developed a set of guidelines and parameters that allow 3D Printing low-alloy martensite (AF9628) into defect-free parts without sacrificing geometric freedom. AF9628 usually exhibits strengths greater than 1.5GPa with 10% tensile ductility, so matching this using SLM would prove to be difficult.

To prevent defect formation during AM, the team first chose a computationally inexpensive welding-inspired mathematical model, the Eagar-Tsai model, to predict the melt pool geometry of a single layer of martensite powder for various laser settings. The model's predicted results were compared to the actual

defects from an experimental run, and tweaked the model to better predict subsequent layers. After numerous refinements and iterations, the team had tested a wide range of process parameters, and formed an SLM processing map for AF9628. A geometric criterion for precisely determining the maximum spacing between hatching lines was also developed, ensuring the team avoided defects caused by insufficient fusion between the layers.

Raiyan Seede, a graduate student and co-author of the study, explained: "Testing the entire range of laser setting possibilities to evaluate which ones may lead to defects is extremely time-consuming, and at times, even impractical. By combining experiments and modeling, we were able to develop a simple, quick, step-by-step procedure that can be used to determine which setting would work best for 3D printing of martensitic steels."

Using their framework, the researchers 3D printed martensite with 1.4 GPa tensile strength & 11% elongation. According to the study, the tensile strength of the martensitic steel was the highest reported ever for any 3D printed alloy.

3D PRINTED GRAPHENE FOR

TRANSPORT MODERNISATION

Sources: azom.com

American engineering firm AECOM recently debuted a 3D printed graphene-infused structure that arches over a railway. By simplifying the installation of digital signaling technology, the new 'CNCTArch' arch has the potential to completely revolutionize railway networks, according to AECOM.

Standing 4.5 meters tall, the novel railway arch is fabricated from a graphene-infused polymer. The graphene material works as a kind of reinforcement for the arch, facilitating a high weight-to-strength ratio. The amount of graphene that is typically necessary to make these kinds of structures are considerably greater than for other applications.

According to AECOM, the CNCTArch would get rid of the need to affix new digital devices to current infrastructure. This benefit could decrease costs associated with installing digital



systems on rail transportation networks.

The CNCTArch was created by AECOM together with Scaled, a 3D printing service provider. The Scaled 3D printing system was comprised of an extruder connected to a robotic arm.

Using this type of assembly, the Scaled printer is able to generate single structures 2 and 3 meters across. According to the company, they are capable of expanding this capability by simply using a larger robotic arm. Scaled's system uses pelletized feedstock to fabricate items due to its faster print times.

AECOM's aim for this research is to eliminate the conventional bolt-and-screws approach of setting up digital systems inside tunnels.

PEEKAY STEEL, AN INDIAN

STEEL FOUNDRY BUYS AM

SYSTEM FROM VOXELJET

Source: voxeljet.com

Voxeljet AG, a leading global technology company for industrial 3D printing solutions, is delighted to further expand its presence in India. The Indian steel casting expert Peekay Steel Castings (P) Ltd has decided to invest in the VX4000, with a Job Box size of 4000 x 2000 x 1000mm. The VX4000 system is one of the world's largest and most productive 3D printers with a build volume of eight cubic meters and a print speed of 54 hours for one full job box. Peekay Steel has chosen the VX4000 system to quickly and economically realize technically demanding projects and to expand into new business areas.

Peekay Steel specializes in the production of high-quality steel castings, predominantly for the Oil & Gas sector, starting from 1 kg to 20 tons per casting. Most of these products require less than four castings. As a result, the time and cost



towards development of patterns can outweigh total project costs. For some complicated castings, that require non-traditional gating, the VX4000 was most suitable.

Peekay Steel has a multi-pronged approach to their VX4000. They not only want to support the foundry industry in India by providing services from their large system, but also plan to set up a high-tech Knowledge Center around their VX4000. This will include a training facility to support educational institutes and the industry alike. An open access of this kind is a means to attract more and more people towards the foundry industry- a much needed paradigm shift.

Peekay Steel will be setting up the VX4000 in a brand new location in Airport City, Bengaluru.



CHINA CONDUCTS ITS FIRST 3D

PRINTING EXPERIMENT IN SPACE

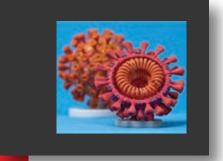
Source: thestar.com.my

China has conducted its first 3D printing experiment in space in a newly launched spacecraft, according to the China Academy of Space Technology.

The academy said on its WeChat account on Thursday that the experiment was done by a 3D printer, developed and built by its Beijing Spacecrafts Manufacturing Factory, inside the prototype of China's new-generation manned spacecraft.

The printer, named the Space-Based Composite Material 3D Printing System, uses carbon fiber-reinforced composites to autonomously print objects. It is installed in the re-entry module of the experimental spaceship and will be brought back to Earth once the module returns.

The academy said the printer features advanced technologies in material modeling, precision control and automation. It explained that upon becoming operational, the 3D Printer can extensively benefit space programs by 3D Printing most of the resupply in space, which otherwise is sent using cargo spacecrafts.



RESEARCHERS REVIEW EMERGING

3D PRINTING MEDICAL DEVICES

DURING COVID-19 PANDEMIC

Source: 3dprint.com

Researchers from the US and Australia take a comprehensive look at how 3D printing technology is being used to help during the current pandemic, releasing their findings in the recently published 'COVID-19 and the Role of 3D Printing in Medicine.'

As humans around the globe are affected by coronavirus disease 2019 (COVID-19), 3D printing users have stepped up to help wherever possible in providing personal protective equipment and medical devices, as well as accompanying parts. Users have created masks, ventilators, connectors, and a variety of other PPEs and parts needed; however, numerous businesses, medical centers, and research scientists have been collaborating, innovating, and supporting 3D printing endeavors too.

The researchers point out also that numerous groups have been working together in community efforts. They delve into many different types of open-source models, but the

resources and files referred to are meant to be part of an 'evolving collection' of models and links to resources for answering immediate medical needs (an example is located at the NIH 3D Print Exchange).

The researchers vouch for open-source products. One such example would be automated ventilators with the Illinois RapidVent design which include 'promising results,' especially when there may be a limited supply from manufacturers.

Sterilization must be taken into consideration for all reusable items. Detailed customization is also possible via 3D printing, with masks such as the Copper3D NanoHack mask (printed with PLA as a flat piece) or the HEPA mask (Thingiverse, by Kvatthro).

They recommend "3D printing experts communicate with local hospital supply chain and potentially with national strategic stockpile holders. A centralized strategic local response to this crisis requires open forms of organized communication".

3D PRINTED TOUCH SENSOR

USING DRAGONFLY LDM

Source: 3dprintingindustry.com

Nano Dimension, a specialist in AM electronics, and REHAU, a leading polymer manufacturer, have announced the successful 3D printing of a 3D touch sensor. Using Nano Dimension's specialized DragonFly LDM (Lights-out Digital Manufacturing) 3D printer, REHAU was able to functionalize one of its premium polymer materials via the integration of an AM electronic circuit.

Released last year, the DragonFly LDM features Nano Dimension's established PCB 3D printing technology, as well as 24/7 "lights-out" automated manufacturing capabilities. The system's unique and non-standard shape printing abilities mean it can be used to additively manufacture multilayer PCBs, capacitors, coils, sensors, and antennas. The machine also sports a self-cleaning printhead and an *in-situ* material monitoring sensor.

The touch sensor was developed as part of REHAU's 'Electronics into Polymers' program, which intends to add value to REHAU's polymer



materials by integrating electronics into them—making them "smarter". In case of the "sleek design" touch sensor, REHAU's customers can now make use of a back-lit human-machine-interface surface for a number of innovative applications. According to REHAU, the program is the company's way of developing better performing, efficient functional devices and lower costs from its premium polymers. This comes in the age of smart homes, smart mobility, and the IoT, so the polymer industry may need to adapt to keep up.

Dr. Ansgar Niehoff, Head of 'Electronics into Polymers' at REHAU, stated, "Smartification is no longer just a vision for us. REHAU is developing improved products for the smart home & IoT environment, and Nano Dimension is providing important technology to help accelerate new applications availability."

IIT MADRAS HOSTS ONLINE

INTERNATIONAL WORKSHOP

ON 3D PRINTED CONCRETE

Source: indiatoday.in

IT Madras collaborated with international and Indian associations to host an online workshop on 'Recent Trends in Science & Technology of Concrete.'

Among the major issues deliberated during this workshop was '3D printing of concrete,' which, with more development, could offer innovative solutions to meet future infrastructure demands including high construction speed, reducing material wastage and creativity in design.

IIT Madras Construction Materials Group joined hands with the Réunion Internationale des Laboratoires et Experts des Matériaux, systèmes de construction et ouvrages (RILEM) and Indian Concrete Institute for the workshop.



The online workshop on May 2nd, attracted widespread attention from countries such as the UK, US, Afghanistan, Australia, Bangladesh, Belgium, Canada, DR Congo, Ethiopia, France, Germany, Ghana, Italy, Kenya, Kuwait, Oman, Qatar, Lebanon, Lithuania, Malaysia, Mexico, New Zealand, Nepal, Nigeria, Pakistan, Philippines, S. Sudan, Saudi Arabia, Somalia, Singapore, UAE, and India.

Faculty of IIT Madras Civil Engineering Department who addressed the sessions include Prof. Manu Santhanam, Head of the Department, Dr. Piyush Chaunsali, and Dr. Radhakrishna G. Pillai. Two other speakers, a US resident and an IITM research scholar also addressed the sessions.



ISRAELI 3D PRINTING STARTUP -

NANOFABRICA, RAISES \$4 MILLION

Source: timesofisrael.com

Nanofabrica, a startup that develops 3D printers for the manufacturing of electronic and optical parts, said Sunday it has raised \$4 million in a funding round led by Microsoft's venture arm M12 and NextLeap Ventures.

The funding will be used to further the startup's research and development work as well as expand its sales, Nanofabrica said in a statement. To date the company has raised a total of \$7 million.

NextLeap Ventures is an investor group made up of former employees of Intel Corp.

The Tel Aviv based startup has developed a 3D

printing technology that enables the mass digital manufacturing of precise and complex parts for semiconductors, optical and medical devices. Nanofabrica was founded in 2016 by Jon Donner (CEO, Nanofabrica).

The startup added that it has been studying ways to use its "ultra-precise manufacturing capabilities" to support efforts to fight the coronavirus pandemic, and is in talks with researchers and manufacturers.

M12 - Microsoft's venture fund, invests in enterprise software companies in the Series A through C funding stages with a focus on infrastructure, security, applied AI, business applications, . M12, in March said it was pulling its investment from an Israeli facial-recognition startup AnyVision, because of concerns regarding the use of its technology.



TAIWAN RESEARCHERS DEVELOP

SELF-HEALING GLASS FOR AM

Source: 3dprintingindustry.com

Researchers from National Central University, Taiwan have developed a UV and heat resistant, self-healing emulsion glass. The impressive arsenal of properties makes the liquid-like solid (LLS) material perfect for a supporting medium, whereby UV and heat-curable inks (aka resins) can be '3D written' directly into it and cured independently of the surrounding LLS.

According to the researchers, LLS materials can be used as a robust supporting medium for liquid inks. Using them to hold the ink in place while the ink solidifies helps maintain the intended written geometry. Without a supporting medium, gravity & surface tension of the ink would result in fluid instability.

With an aim of developing the next-generation supporting media, the research team first mixed water and a specially formulated silicone oil with sorbitol to form an aqueous solution. From this, they extracted a "stable emulsion glass" which would go on to be used as the experimental supporting medium. The research team opted to use PDMS elastomer as the ink which would be 3D written into the emulsion glass and cured. The 3D writing device (a syringe pump with a nozzle diameter of 1.83mm) was constructed from scratch.

3D structures were modelled and written into samples of the emulsion glass and cured with heat and UV light to demonstrate the glass' suitability as a supporting medium. For the UV process, a 365nm UV lamp was used for 60 seconds and for the thermal process, the ink-glass samples were heated in an oven at 100°C for an hour. Even after six runs of UV and heat exposure, the emulsion glass remained unphased and maintained its structural integrity, This gave the glass its UV and heat resistance and meant that the glass could be used to cure UV and heat-sensitive inks at the same time.

NEW REVOLUTIONARY METAL

3D PRINTING TECHNOLOGY

Source: 3dprintingprogress.com

 ${\sf S}$ elective LED-based melting (SLEDM) - i.e. targetted melting of metal powder using highpower LED light sources - is the name of the new technology that a team led by Franz Haas, Head - Institute of Production Engineering at TU Graz, has developed for 3D metal printing. The team has now applied for a patent for the same. The technology is similar to selective laser melting (SLM) and electron beam melting (EBM), in which metal powder is melted by means of a laser or electron beam and built up into a component layer by layer. However, SLEDM solves two central problems of these powder bed-based additive manufacturing processes: manufacturing of large-volume metal components and manual postprocessing, both of which are highly time consuming.

Unlike the SLM or EBM processes, the SLEDM process uses a high-power LED beam to melt the metal powder. The light-emitting diodes used for this purpose were specially adapted by the west Styrian lighting specialist, Preworks



and equipped with a complex lens system by which the diameter of the LED focus can be easily changed between 0.05 and 20 millimetres during the melting process. This enables the melting of larger volumes per unit of time without having to dispense with filigree internal structures, thus reducing the production time of components for fuel cell or medical technology, for example, by a factor of 20 on average.

This technology is combined with a newly designed production plant, which - in contrast to other metal melting plants - adds the component from top to bottom. The component is thus exposed, the required amount of powder is reduced to a minimum and the necessary post-processing is carried out during the printing process, eliminating manual re-working stress of current methods.

NSCRYPT & TECHSHOT HAVE

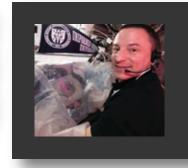
3D BIOPRINTED A HUMAN

KNEE MENISCUS IN SPACE

Source: 3dprintingindustry.com

Microdispensing specialist nScrypt and aerospace company TechShot have successfully completed the first functional 3D bioprinting experiment in space. Using the BioFabrication Facility (BFF) on board the ISS, with the help of the non-profit Geneva Foundation and the Uniformed Services University of the Health Sciences (USU), they 3D bioprinted a human knee meniscus as part of the 4D Bio3 program. The breakthrough experiment is part of a long term plan to one day manufacture advanced soft tissues and whole organs in the microgravity of space.

The BFF has been documented as the world's first 3D printer capable of fabricating human tissue in space. It uses pluripotent stem cells to generate viable tissue by organizing fine layers



of bioink precisely – a few microns across – in specified patterns. The stem cells are nurtured and differentiate into the desired human cells over time, eventually forming into cultures of tissue. This is extremely difficult (impossible thus far) to accomplish on Earth due to the relatively strong gravitational force. On Earth, soft tissues collapse under their own weight, leaving researchers with a fluid mess of jumbled up cellular connections. On the ISS, Earth's gravitational pull is much weaker. This enables the 3D printed soft tissues to maintain their shape.

The BFF was initially launched in July of 2019, and has received a number of upgrades over the course of a year.



EXPANDABLE FOAM FOR 3D

PRINTING LARGE OBJECTS

Source: 3dprintingprogress.com

It's a frustrating limitation of 3D printing: Printed objects must be smaller than the machine making them. Huge machines are impractical for printing large parts because they take up too much space and require excessive time to print. Now, a new material reported in ACS Applied Materials & Interfaces can be used to 3D print small objects that expand upon heating. The foam could find applications in architecture, aerospace and biomedicine. For further information see the IDTechEx report on 3D Printing Materials 2019-2029: Technology and Market Analysis.

Stereolithography, creates objects by exposing

sequential layers of light-sensitive resins to patterns of light, which cure the polymer into the desired shape. Large objects can be created with specialized stereolithography machines. David Wirth, Jonathan Pokorski and colleagues at the University of California, San Diego wanted to develop an expandable resin that could print large objects with an inexpensive, commercially available 3D printer.

Researchers tested many different resin formulations to find one that allowed them to print an object that, when exposed to heat, expanded to a larger size. They used the formulation to 3D print a hollow, latticed sphere. Heating the sphere in an oven caused a volatile component of the resin to bubble out as a gas. This created a porous, polystyrene foam-like material that was up to 40 times larger in volume than the original object.



HOW NASA'S 3D PRINTERS TEST

RECYCLING PLASTIC IN SPACE

Source: fedtechmagazine.com

Nasa's 3D printing program began with making tiny wrenches and may end up building infrastructure on the moon. In between those moments, however, astronauts aboard the International Space Station are testing technology designed to make the printing process more efficient.

The space station is currently home to two 3D printers, one known as the Refabricator and another called the Additive Manufacturing Facility (AMF). A third device, the Recycler, is designed to recycle used material to save room and weight on the ISS, much like the Refabricator. Each works in a slightly different way, and astronauts are trying to determine which works best.

The first recycling printer sent to the ISS, the Refabricator, has been on board for a year. It was designed to recycle 3D printed plastic into

parts and tools that are then sent back to Earth for analysis to see how the recycling process affects the basic structure of the plastic.

Currently, astronauts are testing only the bonding properties of the recycled material; an anomaly is preventing them from further demonstrations of the print and recycling functions, Clinton says. The Refabricator will be coming back to Earth in December for a comprehensive evaluation.

While using recycled material for printing will be handy on board the ISS, it will be even more valuable during Artemis, the planned crewed mission which will put the first woman on the moon in Phase 1 and explore building capabilities for future expeditions to Mars in Phase 2.

3D printing could help future astronauts build a base on the moon, Clinton says, creating buildings, roads, landing pads and other civil engineering works — and NASA plans to use dirt from the moon itself.

SCIENTISTS 3D PRINT

RECONFIGURABLE LIQUID

METAL LATTICE

Source: 3dprintingindustry.com

Scientists from Binghamton University's Watson School of Engineering have used 3D printing to produce a reconfigurable liquid metal lattice hand.

Created by combining liquid metal with a 3D printed shell skeleton, the metal appendage would not look out of place as part of the shape-shifting T-1000 terminator. The novel hybrid manufacturing approach integrates 3D printing, vacuum casting, and conformal coating to produce a shape memory effect, which holds the lattice material in place within any pre-designed shell.

The technique furnishes the metal lattice with recoverable energy absorption, tunable rigidity, and reconfigurable behaviour. This lends itself



to maintenance and repair applications in the aerospace industry, according to the Binghamton scientists.

The production process begins with the 3D printing of a shell skeleton out of rubber and metal using a commercial Digital Light Projector (DLP) printer. The skeleton is then filled with hot liquid metal lattice which is produced using Field's alloy, a metal used as a liquid coolant in nuclear engineering due to its low melting point of 62oC. As the lattice is allowed to cool, it becomes more malleable, allowing it to be fitted into any shape or design. When the metal is heated to melting point, it takes a liquid form, and is ready to be reused and reshaped.

VARSITY PROFESSOR USES

3D PRINTING TO ADVANCE

CANCER RESEARCH

Source: 3dprintingindustry.com

An assistant professor from the Virginia Commonwealth University (VCU) College of Humanities and Sciences has used 3D printing to create live models of tumor cells, which could enable cancer researchers to better understand the disease's progression.

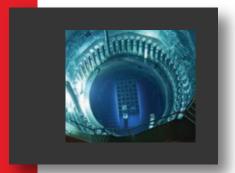
Assistant professor Daeha Joung worked alongside a team of researchers led by Dr. Michael McAlpine at the University of Minnesota (UMN), that invented the novel method of building tumor constructs. The new technique allows for the precise placement and control of living cells, to more effectively mimic the key steps of cancer dissemination. Now at VCU, Joung is using this approach to enable the university's Massey Cancer Center investigators, to maximize cancer cell growth for study, and evaluate the effectiveness of anticancer immunotoxins. Massey scientists will be able to provide cancer tissue samples to



Joung, and then prescribe specific designs or tumor structures they need to have manufactured. Using robotic mechanisms and customized 3D printing technology, Joung will then adjust the amount and specific configuration of the types of cells being replicated and printed.

This, in turn, could enable future researchers to screen novel anticancer drugs, and test patient-specific strategies for diagnosis and therapeutics. "Cancer is cancer from an engineering point of view, so my lab can produce many different types of tumor tissuemimics," said Joung.

Joung's ambition is to design a comprehensive platform of advanced 3D systems for application in cancer neural regeneration models, opening novel opportunities to test therapeutic options to treat disease.



WORLD'S FIRST 3D PRINTED

NUCLEAR REACTOR CORE

Source: oilprice.com, powermag.com

Researchers in the Department of Energy's Oak Ridge National Laboratory are 3D printing the nuclear reactor core, with plans to have the first one up and running by 2023.

"The nuclear industry is still constrained in thinking about the way we design, build and deploy nuclear energy technology," the director of the Oak Ridge National Laboratory said in a news release. "DOE launched this program to seek a new approach to rapidly and economically develop transformational energy solutions that deliver reliable, clean energy."

The core will comprise a "conventionally manufactured" and qualified vessel made from grade 304H stainless steel, 3D printing will be applied to the silicon carbide matrix that will contain uranium nitride tristructural-isotropic (TRISO) fuel particles, a type of HALEU fuel.

ORNL, a globally recognised developer of micro-encapsulated fuel technologies, has already done the brunt of development work, including manufacturing and early irradiation of the novel fuel particles. The additively manufactured silicon carbide and fuel particles offer significantly higher uranium density over historic manifestations of coated fuel particles and "may be more optimal for a range of advanced reactor applications," especially those with small cores, said Terrani.

Terrani noted the Additive Manufacturing technologies in use at the project have been customised to meet its tight schedule. Some components will be printed with commercially available laser powder bed fusion technology, but for its ceramic components, it uses an ORNL-invented process that combines commercial binder jetting technology with chemical vapour infiltration. "That gives us this extremely high purity, fully crystalline nuclear-grade carbide material that we want," he said.

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Belgian AM Company, Materialise 3D Printed the crown. The movie went on to win an Oscar for its costume design.

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